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(54) **BLAST FURNACE WITH NARROWED TOP SECTION AND METHOD OF USING**
HOCHOFEN MIT VERENGTER HAUBE UND VERFAHREN ZU DESSEN VERWENDUNG
HAUT FOURNEAU A REGION SOMMITALE RETRECIE ET METHODE D'UTILISATION

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BE-A- 817 647 **FR-A- 535 528**
GB-A- 1 079 701 **US-A- 1 917 642**
US-A- 2 952 533 **US-A- 3 623 717**

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Description**BACKGROUND OF THE INVENTION**

5 **[0001]** This invention relates to an apparatus and method for efficiently converting a diverse material input into useful by-products and energy with a minimum of waste and pollution.

[0002] It has now been discovered how the design of mankind's two oldest large industrial tools, the blast furnace and the slagging-ash gas producer can be combined into that of a Zone Controlled Multi-Purpose Slagging-Ash Oxygen Jet Blast Converter (Improved Converter) which as the primary converter in an integrated closed loop, can help solve
10 some universally urgent problems by directly or indirectly completely converting a wide range of materials, including in its four modes of operation: wastes, non-premium carbonaceous materials, oil shales and metallic oxides into desirable needed products, It has the best characteristics of both parents plus some attractive unique ones while minimizing undesirable characteristics.

[0003] Both parents since prehistoric times, even when their construction was crude, have been safely converting
15 at high temperatures all the raw materials charged in at the top into molten metals and molten slags, gases, vapors and dusts, but conventional blast furnaces when they produce one ton of molten pig iron still produce approximately six tons of an inferior 70-90 Btu/cf. top gas. Further, today's large capacity blast furnaces function well only when charged with premium raw materials and the designs of conventional slagging-ash converters of all kinds being used have never been modernized to provide a method of precisely regulating the conversion activities taking place as the
20 charge entering at the top moves down counterflow to the gas stream generated near the bottom by a mainly hot air blast.

[0004] There currently is a need for conversion systems that convert substantially 100% of all the input materials into desirable outputs. The health of the world is being increasingly threatened by air, water and land pollution related to the generation and disposition of wastes of many kinds by dumping, burying, incinerating, and releasing them into
25 the air. Conversion residuals such as nitrogen oxides, hydrocarbons, sulphurous gases, and chemical compounds with a soluble toxic chemical content are polluting our air, land and water. Nature's live plant converters are being poisoned by the chemical content of acid rain and smog produced mainly when petroleum products and coals of all kinds are burned and the fumes released into the air. Commonly used high Btu content fuels are producing nitrous oxides which are especially dangerous because of their depleting effect of ozone layer. Crude oil reserves are rapidly being depleted
30 and employing atomic energy to produce electrical energy has created serious new pollution problems.

[0005] US patent specifications 3814404, 3928023, 4381938 and 4495054 all introduce the concept of regulating activities within three temperature-controlled zones in a blast furnace by installing strategically-located auxiliary tuyeres (openings in the side of the furnace) through which gases and other materials can be injected or withdrawn. The basic aim except in US 4495054 was to produce molten metal from metallic oxide ores by employing less high temperature
35 reducing gas generated internally from premium coke prepared externally from superior coals. US 4495054 describes how a blast furnace can be improved into a zone controlled slagging-ash gas producer. It recognises the desirability of employing a 100% oxygen blast, but describes no method of protecting the gas producer's refractory walls from the high flame temperatures such a practice produces. US 4381938 describes an improved blast furnace able to function as either a blast furnace or a slagging-ash gas producer.

[0006] This invention involves improvements on these zone control concepts in order to maximise performance of
40 the blast furnace and achieve other desired results.

Summary of the Invention

[0007] The present invention is directed to a converter, a blast furnace modernised in such a manner as to make it
45 practical to safely and effectively continuously employ a 100% oxygen jet blast and be operated so as to consume, by conversion, a wide range of mostly non-premium raw materials including wastes of many kinds including a wide range of toxic and hazardous wastes, oil shales and sands and other inferior or difficult to process economically in an ecologically desirable manner raw materials. These are converted into fuel gases, molten metal, molten slag, vapours and
50 dusts. Some conversion products are usable as produced and the balance are converted in the other production units in the system. A process control computer and auxiliary tuyere inputs and outputs are employed to precisely regulate the temperature controlled activities taking place in the three converter zones and the quality of the outputs. Sensors are located at each of the five tuyere sets and at the top and bottom which are input to the process control computer. Gas samples are taken at tuyere sets T3, T4 and T5. These results are input to the process control computer giving
55 it the information required to schedule periodic purges through the appropriate tuyere sets when an undesirable build up of recycling materials has occurred.

DESCRIPTION OF THE DRAWINGS

[0008] The invention is described by way of example in the following detailed description, taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a schematic, cross-sectional view of the converter according to the invention; and

FIG. 2 is a flow diagram showing the "Improved Converter System" incorporating a converter according to the invention.

DESCRIPTION OF THE IMPROVED CONVERTER AND METHODS OF OPERATION

[0009] The primary conversion unit in "Improved Converter Systems" will be a converter. The configuration almost identical to a modern blast furnace except for the following major improvements shown in Figure 1, Conceptual Cross Section of converter. The largest diameter of the stack (at the interface between zone #2 and zone #3) is reduced approximately 25-30% in region 2, and in region 4 the stack 5, tapers from the conventional diameter to the reduced diameter. Region 4 extends from a point on the stack where the temperature is controlled close to, but never above 480°C, where the stack starts to taper at the top of Region 4. Region 4 may extend from approximately 85% of the stack height above the bosh and to about 75% of the stack height above the bosh. This modification prevents oil shale or some carbonaceous grate forming materials, which swell as they are coked, from prematurely absorbing enough heat to begin expanding and creating a pinch point in this portion of the stack. The solid materials are charged at the top of the stack 10 as in conventional practice.

[0010] The five sets of tuyere sets are employed, so as to make it possible to create and more precisely control three distinct temperature zones of activity within the converter. Gases, vaporized materials, liquids and dusts are input through tuyere sets T1 and T2 in the bosh 3 in Zone #1 and withdrawn through three tuyere sets T3, T4, and T5 and the top 9. The tuyere openings are located at strategic points in such a manner as to achieve a more precise than conventional converter temperature profile and/or extract products. Sensing devices are installed at the top and all five tuyere sets and the crucible which are input converter temperatures at various heights to the process control computer along with the results of gas analyses of gas samples taken periodically at tuyere sets T3, T4, T5, and the top.

[0011] Zone #1 is formed by injecting a computer-calculated amount of gaseous, liquid, vaporized or dust like endothermic reacting materials such as steam, carbon dioxide, wastes in gaseous, liquid or dust forms, and hydrocarbons through an endothermic reacting material injection system placed in tuyere set T1 located below tuyere set T2. Tuyere set T2 is located where in conventional practice the hot air blast is introduced and is employed to introduce oxygen. It houses oxygen jet blast nozzles and a peripheral injection system for endothermic material. The injection pressure employed at T1 tuyere set is variable but always only slightly greater than that prevailing in the bosh. An annular gaseous flame buffer, Zone #1, is created in this manner in front of tuyere sets T1 and T2. It protects the refractory walls in this portion of Zone #2 from the high flame temperatures. The materials injected through tuyere set T1 tend to move up instead of into the center of the bosh.

[0012] Consuming the endothermic reacting peripheral content of the oxygen jet blast (which may be 100% oxygen) entering though the jet nozzles located in tuyere set T2, for a short distance prevents it from producing a high flame temperature as it races through Zone #1 at a pressure much above (eg: up to double) that prevailing in this portion of the converter. The much larger endothermic reacting input through tuyere set T1 is converted to H_2 and CO. The heat consumed by these endothermic reactions modifies the flame temperature in Zone #1 enough to protect the refractory walls, injection systems and tuyeres in this area from the high flame temperatures generated in Zone #2 in front of tuyere set T2.

[0013] Zone #2 is operated essentially as a high temperature process heat and reducing gas generation zone where the final conversion of the down moving burden to a gas, vapour, molten slag, or molten metal takes place. It includes all the bosh not in Zone #1. The oxygen consumption of the oxygen jet streams with their, peripheral, endothermic reacting content, is minimal when they pass through Zone #1. The streams mainly consume the carbonaceous grate in Zone 2 at high flame temperatures (2300° - 2600° C) which are conducive to the reactions $C + O_2 = CO_2$ and $CO_2 + C = 2CO$ and $H_2O = H_2 + \frac{1}{2}O_2$. These gases form the main ascending gas stream which to a degree is modified in temperature by the endothermic input from Zone #1 which is maintained within a 800° - 1200°C temperature range by regulating the endothermic reacting input through tuyere sets T1 and T2.

[0014] Zone #3 starts at the top of the mantel 8 and includes the entire stack. It is regulated through three tuyere sets. Tuyere set T3 is located just, eg: about 0.61m (2 feet) above the mantel. The temperatures at this level are regulated by the volume of oxygen input through tuyere set T2 and or the endothermic reacting materials input through tuyere sets T1 and T2. Tuyere set T4 is located above the mantel approximately 25% of the distance between the mantel and the top of the stack. The temperature at the Tuyere set T4 is maintained near 850 °C and the temperature of the transition section 4 at close to 480°C at the top end by regulating the volumes of gas withdrawn through T3.

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Tuyere set T5 is located further up the stack (approximately 42% of the distance above the mantel) where the stack temperature is maintained near 760°C by regulating the amount of gas withdrawn through tuyere sets T3 and T4. The temperature at the top of the stack is maintained between 300° - 400°C by regulating the volume of gas removed through tuyere T3, T4, T5 and the endothermic input through T1 and T2. The output 9 of a top gas collection system removes gaseous products of carbonization and/or volatilization, including carbon monoxide, hydrogen, hydrocarbons, hydrogen sulfide, oxides of sulfur, nitrogen, ammonium, light oils, and steam. The above locations as well as the location of the regions of the improved converter recited earlier generally can vary by 4% from the figure recited.

[0015] The coke and char constituents, which reform from above the carbonaceous grate consumed in Zone #2 (except in the high volume molten metal production mode), are internally manufactured in Zone #3 from non-premium coals and other carbonaceous materials charged at the top and move downward by gravity as the portion of the grate below them is gasified. Their temperature is controlled by regulating the amount of gas passed through the zone and its entering temperatures so that they are never lower than 1000°C when they reach the bottom of Zone #3. In this way the traditional loss of sensible heat incurred when coke is produced outside of a blast furnace, then quenched and cooled before charging, is completely avoided, except when operating in the high molten metal production mode and then only partially.

[0016] A typical medium size conventional blast furnace produces 2,500-3,150 tons of hot metal (pig iron) while consuming 8,000-10,000 tons of solid charge consisting of iron bearing oxides, coke, and other additives. Source: Blast Furnace -- Theory and Practice, Volume 1, Gordon and Breach Science Publishers, New York, London, Paris.

TABLE 1

Blast-Furnace Dimensions		
Hearth Diameter	8.84m	(29 ft 0 in)
Bosh Diameter	9.88m	(32 ft 5 in)
Top Diameter	6.86m	(22 ft 6 in)
Bell Diameter	5.03m	(16 ft 6 in)
Hearth Bottom to Iron Notch	0.61m	(2 ft 0 in)
Iron Notch to Cinder Notch	1.42m	(4 ft 8 in)
Cinder Notch to Tuyeres	1.07m	(3 ft 6 in)
Tuyeres to Bend Line	0.41m	(1 ft 4 in)
Height of Bosh	3.35m	(11 ft 0 in)
Height of Vertical Section	2.13m	(7 ft 0 in)
*Height of Sloped Inwall	17.68m	(58 ft 0 in)
Bend Line to Hopper Ring	6.71m	(22 ft 0 in)
Total Height Iron Notch to Top Ring	32.92m	(108 ft 0 in)
Working Height (Centerline of Tuyeres to Stockline, -6 ft Below Large Bell Closed)	25m	(82 ft 0 in)
Working Volume	1471429 L	(51,500 cu ft)
Bosh Angle		81° 33' 22"
Inwall Batter	0.086m per.m	(1.03 In. Per. Ft)
No. of Tuyeres		24
No. of Columns		8

*Calculated Taper of Sloped Inwall 0.08m/m (1.02 in/ft)

[0017] An improved converter of this invention can exhibit nearly the same dimensions as the referenced middle size conventional blast furnace with exceptions of 25-30% reduced diameter of 15% of the top stack height (ref. Fig 1 Region 2) and an increased tapered stack in Region 4 comprising approximately 10% of the stack height which interconnects with the top reduced diameter of the stack and the stack of Region 5 exhibiting conventional constant taper.

[0018] In addition to these modifications the improved converter employs five sets of tuyere sets strategically located in the hearth and the stack above the bosh. Improved converter dimensions and location of the tuyere sets can be shown in Table 2.

TABLE 2

Hearth Diameter	8.28m	(27 ft 0 in)
Bosh Diameter	9.30m	(30 ft 6 in)

TABLE 2 (continued)

Reduced Top Stack Diameter	3.66m	(12 ft 0 in)
Reduced Diameter Top Stack Height	3.51m	(11 ft 6 in)
Bottom Diameter of Tapered Stack Interconnection	6.10m	(20 ft 0 in)
Height of Tapered Stack Interconnection (Region 4)	2.44m	(8 ft 0 in)
Stack Interconnect Taper (Region 4)	0.47m/m	(5.6 in/ft)
Height of Bosh	3.35m	(11 ft 0 in)
Height of Vertical Section	6.10m	(20 ft 0 in)
Height of Stack with Constant Taper	15.85m	(52 ft 0 in)
Stack Constant Taper (Region 5)	0.10m/m	(1.23 in/ft)
Total Stack Height Top of the Bosh Top The Top Stack	21.64m	(71 ft 0 in)
Total Height Iron Cast Hole to Top Stack	34.14m	(112 ft 0 in)
Tuyere Set T ₁ above Iron Casting Hole	2.29m	(7 ft 6 in)
Tuyere Set T ₂ above Iron Casting Hole	3.66m	(12 ft 0 in)
Tuyere Set T ₃ above Bosh	0.61m	(2 ft 0 in)
Tuyere Set T ₄ above Bosh	5.49m	(18 ft 0 in)
Tuyere Set T ₅ above Bosh	8.84m	(29 ft 0 in)

[0019] Dimensions of conventional blast furnace and/or improved converter can vary with the installed capacity.

CONVERTER SYSTEM

[0020] By making the changes in the design of modern blast furnaces described herein, and illustrated in Figure 1, it is practical to modernise them into converters able to operate effectively in four different modes depending on the major objectives sought. In two of the four modes they demonstrate their capacity as the primary converter in universal Improved Converter Systems designed to completely convert, in Mode #1, wastes of many kinds into desirable products and, in Mode #2, oil shales and oil sands completely into desirable products without causing pollution of any kind. In Mode #3, the converter functions as an improved slagging-ash gas producer designed to produce a maximum volume of low cost clean burning gases from non-premium carbonaceous raw material sources without causing pollution. In Mode #4 the converter functions without causing pollution, as an improved (less coke consumed, no stove costs, longer lining life) high volume molten metal producing blast furnace also simultaneously producing a superior gas removed out the top (2,492,000 to 2,670,000 cal/m³ (280 to 300 Btu/cf.)).

[0021] In all modes a high finished product yield is obtained by completely converting all incoming materials into a highly desirable boiler fuel gas, reducing gas to feed stock from which methanol is synthesised as withdrawn through tuyere set T3 with only minor processing, or into gases, molten metal and slag, vapours and dusts consumed in dependent production units in the fully integrated closed loop. The high flame temperatures used in the maximum temperature portion of Zone #2 produce enough high temperature heat to completely convert all input materials.

[0022] Some of the other products withdrawn at tuyere sets T4 and T5, the top and the slag notch 6 and casting hole 7 are finished products as withdrawn. Others can constitute raw materials streams to other production units in the integrated Improved Converter System where they are converted to finished products. Referring to Figure 2, these production units include but are not limited to some combination of Waste Heat Boilers 11, 12, 13; a Ferrous Oxide Direct Reduction Plant 15; Steel Making Facilities 16; a Foundry 17; a By-products Plant 18; an Electrical Energy Generation Plant 19; a Processing into Building Materials unit 20; a Sulphur Products Plant 21 a synthetic polymer facility, such as a Synthetic Rubber or Fibre and Plastics Plant 28; a CO₂ rich atmosphere superior food strain of Blue-green Algae Greenhouse Tank Farm 22. Optionally another tandem operation converter 29 can be operated in the high molten metal production mode. Supporting units include Material Preparation Plant 14, Endothermic Materials Storage 24; Oxygen Production Plant 25 and Nitrogen Storage 26.

[0023] The by-products stream is converted in the By-products Plant 18 into a variety of products including, but not limited to: a clean-burning pipeline gas with a 3,560,000 to 5,340,000 cal/m³ (400 - 600 Btu/cf.) energy content; fertilisers; clean-burning fuels which will be ideal substitutes for gasoline, diesel fuel and jet propulsion fuel; a synthetic rubber, fibre and plastics products stream; industrial chemicals, and black top tar.

[0024] The Slag Processing unit 20 can produce, from the acidic slags, superior ingneous rock castings, e.g., of an interlocking type suitable for use in residential construction and other structures of many kinds. They are fireproof, insect-proof, require no maintenance, have excellent insulating qualities and facilitate rapid, low-cost construction. The

basic slags, without remelting, can be converted into specification cements or rock wool insulation.

[0025] The Waste Heat Boilers 11, 12, 13 can produce steam; convert vaporous kerogen to a readily processed liquid which, in the By-products Plant, can be converted into substitutes for gasoline and other by-products; convert recycling metal vapours including sodium, potassium, and zinc to metallic dusts or droplets and also separate out NaCN and KCN. They Synthetic Rubber and Fibre Plant 28 can convert the incoming raw materials stream from the By-products Plant into a wide variety of synthetic rubber, plastics, and fibre products.

[0026] In all modes, except Mode #4, the high volume metal production mode, the molten metal periodically withdrawn from the casting hole 7 in the conventional manner will be delivered to the Foundry 17 where any necessary separation of the different metals takes place or delivered directly to the steel making facility.

[0027] To achieve the objectives set forth above, the converter has been designed and is operated in any of the four modes so as to handle a very large volume of diversified materials charged in at the top 10. An average size converter is able to process approximately 8,128,000 to 10,160,000 kg (8,000 to 10,000 tons) of material per day. The size of the chunks of material charged normally vary from a minimum 0.635cm (1/4") to a maximum of 20.32cm (8") in any one dimension.

[0028] When the major objective is disposal of wastes in an improved manner, the materials charged at 10 and those removed from the top 9, tuyere sets T3, T4 and T5, the molten slag notch 6 and the molten metal casting hole 7 are somewhat different from the input and outputs when the main objective is to convert oil shales into clean-burning fuels and many other beneficial products or convert non-premium carbonaceous materials into gases, or convert metallic oxide materials into molten metal. An essentially 100% oxygen jet blast is, however, employed in all modes of operation. It carries in with it a peripheral endothermic input as it is released through tuyere set T2 at a pressure high enough (e. g: about double) above that prevailing in this bosh portion of the converter to make certain it passes rapidly through Zone #1 and penetrates deeply into Zone #2. The advantages of substituting a relatively high pressure 100% oxygen jet stream blast for the conventional hot air blast are to: (1) eliminate the need for blast heating stoves; (2) improve the movement of the burden down the stack by greatly reducing the ascending gas volume per lb of carbon consumed and by increasing the central portion of the carbonaceous grate consumed; (3) improve the quality of the gases produced by eliminating the nitrogen content introduced in the conventional hot air blast; (4) increase the generation of high-temperature sensible heat by safely using high flame temperatures, and, as a consequence the magnitude of endothermic reactions that are practical; (5) increase the operating rate. The gas continuously removed through tuyere set T3 and passing through the Waste Heat Boiler and the Trace Sulphur Remove System to remove vaporous materials will have a heat energy content of 2,492,000-2,670,000 cd/m³ (280 - 300 Btu/cf.), making it a high efficiency boiler fuel, superior even to natural gas because it burns with a lower flame temperature and, consequently, no harmful nitrogen oxides will be formed. This gas is also an ideal raw material gas for use in synthesising methanol and other products because it is almost entirely free of air-poisoning sulphur compounds, hydrocarbons and nitrogen oxides formed when an air blast containing large amounts of nitrogen is employed.

Modes of Operation

[0029] When the major objective is to consume waste in an ideal manner, the charge at the top 10 can contain waste materials of many kinds, including municipal and industrial wastes such as tires, automotive wastes, pesticides, sludges of many kinds, waste oil, PCBs and other hazardous and toxic, organic and inorganic materials. Unsorted municipal waste typically contains up to 8% (national average) metallic content. Hagerty, D., Pavoni, J., Heer, J., Solid Waste Management, D. Van Nostrand Company, Inc., New York. Enough basic slag constituents conventionally are added to the charge entering through the top to produce the basic slag needed to remove the inorganic sulphur in the charge. To facilitate the production of specification cement clinker slag in the Slag Processing Into Building Materials Unit 20 chemical additions may be input into the more precisely controlled slag. The ratio of non-premium coal and other carbonaceous grate forming material charged per ton of wastes input will be relatively small, 0.25 to 0.7 because of the carbonaceous content of most wastes.

[0030] The following is a calculated example illustrating this process for the conversion of municipal and industrial wastes into clean fuel gases and a basic slag suitable for conversion into specification cement clinker and other by-products:

TABLE 3

CHARGE		
	kg	(lbs)
Multiple Solid Wastes	635	(1,400)
Tires	91	(200)
Sludges	45	(100)
Toxic Wastes	23	(50)
Slag Building Materials	113	(250)
Non-Premium Coal	318	(700)
Commercial Oxygen	324	(715)
Steam	273	(602)
TOTAL	1,822	(4,017)

PRODUCT						
	kg	(lbs)	m ³	(cf.)	cal/m ³	(BTU/cf)
T4, T5 and Top Gas	576	(1,251)	846	(29,887)	4,957,000	(557 dry)
T3	722	(1,592)	816	(28,809)	2,670,000	(300 dry)
Tar	24	(53)				
Light Oil	7	(15)				
Pig Iron	54	(118)				
Non-ferrous Metals	24	(52)				
Basic Slag	303	(667)				
Water	16	(35)				
Dust	10	(35)				
Total	1,727	(3,818)				

[0031] The non-carbonaceous content of the charge as it descends is converted by the ascending gas stream to gases, vapours or molten materials which trickle down through the carbonaceous grate. The metals (mostly molten iron) accumulate in the bottom of the hearth and a layer of slag forms on top of them. On their way down to the crucible the molten iron captures a maximum amount of the inorganic sulphur released when the carbonaceous grate is consumed in front of tuyere set T2. It releases most of it to the slag layer as it passes through it.

[0032] Referring to Figure 1 it will be noted that the portion of the gas produced in Zones #1 and #2, which is not required in Zone #3 or which must be removed through tuyere sets T4 and T5 to prevent an excessive build up of recycling materials is withdrawn through tuyere set T3. Its temperature is closely controlled and its hydrogen and carbon monoxide content make it an ideal reducing gas to use externally without further processing (Ref. U.S. Pat. No. 4,381,938) in the dependent zone-controlled molten iron producing blast furnaces 29, as a substitute for a portion of the gas which in conventional practice is generated from the combustion of blast furnace quality coke, or in a Ferrous Oxide Direct Reduction plant 15 the product from which is consumed by an electric arc furnace or oxygen blown converter 27.

[0033] In this mode of operation only minor ladle additions are required to produce a basic slag (suitable for manufacturing specification cements). Approximately 400 to 700 pounds of slag is generated per ton of waste charged. Approximately only one half of all the gas generated in the bosh in Zone #2 is required in Zone #3 to convert the carbonaceous portion of the charge to coke or char and either put the other materials into gaseous or vaporized form or preheat them to 1000°C before they reach Zone #2. When the output from tuyere set T3 is not used as a reducing gas it will be passed through waste heat boiler 13 and trace sulfur removal system 23. The emerging gas is an ideal clean-burning, high-efficiency boiler fuel with a 2,492,000-2,670,000 cal/m³ (280-300 Btu/cf.) energy content. When it is consumed, e.g., in the Electrical Energy Generation Plant 19, the stack gas composed almost entirely of CO₂, H₂O and N₂ (no nitrous oxide) is an ideal input into the Blue Green Algae Greenhouse Tank Farm 22 or its components may be separated in the By-products Plant and the CO₂ sold in some form or recycled as endothermic input to the

converter through tuyere sets T1 or T2 or used in the By-products Plant 18 to synthesize products.

[0034] When a pipeline quality gas is desired 3,560,000 to 5,340,000 cal/m³ (400-600 Btu/cf.), all the materials removed through tuyere sets T3, T4 and T5 and the top are delivered to waste heat boilers 11, 12 and 13 and then are sent to the trace sulfur removal system 23. The total gaseous output of the trace sulfur removal system 23 containing products of destructive distillation are sent to the By-products Plant 18, where pipeline quality gas is produced. The liquid output of the trace sulphur removal system 23 is delivered to the Sulphur Products Plant 21. The molten metal formed is removed periodically in the conventional manner and sent to the Foundry 17 where, if necessary, the non-ferrous metals are separated before the molten iron is processed to finished products in the Foundry 17 or delivered to the Steel Making Facilities 16.

[0035] When the chemically and temperature controlled molten slag is periodically withdrawn it is delivered to the Slag Processing Into Building Materials Unit 20. There any additional chemical additions required to produce specification cement clinkers are stirred into the molten slag before it is cooled and ground into cement, or blown to produce rock wool insulation.

[0036] When the objective is a maximum output of clean-burning gases, the converter is operated in Mode #3. The amount of carbonaceous material input at the top 10 is increased. Much of the increase may be of biomass origin. The material flow is the same as when operating in the waste conversion Mode #1. The top gas contains more of the materials separated out in the By-products Plant and sent to the Synthetic Rubber Fibre and Plastics Plant 28.

[0037] When the objective is to convert oil shale or oil sands in a desirable manner the converter is operated in Mode #2. The charge of the top 10 is oil shale or oil sands and non-premium coal or coke breeze in a ratio ranging from .6 to 1.2 per ton of oil shale or sands. U.S. Patent 4,495,054 walled attention to Zimmerman's, book "World Resources and Industries in which he reported that in the U.S. alone, there is one trillion of barrels of kerogen oil recoverable from oil shale. This amount is three times the world's known total crude oil reserves. Kerogen can be refined into fuels which are superior to those made from crude oil. No additional slag-forming components are added, and the large volume of slag produced from the conversion of oil shale or oil sands is acidic. Approximately 70% of the gas generated in Zone #2 is required in Zone #3. The following is a calculated example of this process for extraction of kerogen, gases and other products from oil shale and carbonaceous materials:

TABLE 4

CHARGE		
	kg	(lbs)
Oil Shale *	907	(2,000)
Non-Premium Coal	680	(1,500)
Commercial Oxygen	229	(505)
Steam	202	(445)
TOTAL	2,018	(4,450)

* Based on properties of oil shale from largest US oil shale deposit, Green River Basin
- Colorado

PRODUCT						
	kg	(lbs)	m ³	(cf)	cal/ m ³	(BTU/cf.)
T4, T5 and Top Gas	718	(1,583)	801	(28,300)	4,450,000	(500 dry)
T3	229	(505)	268	(9,475)	2,670,00	(300 dry)
Kerogen	103	(228)				
Light Oil	9	(19)				
Tar	30	(66)				
Pig Iron	48	(106)				
Acidic Slag	317	(1,581)				
Na (Metallic)	24	(52)				
K (Metallic)	5	(12)				
Water	121	(267)				
Dust	14	(31)				
Total	1,618	(4,450)				

[0038] As the oil shale descends and the outside portion of each piece of shale reaches 480°C it starts releasing liquid kerogen and expanding 50% by volume. McGraw-Hill Encyclopaedia of Science and Technology, D. Van Nostrand Company, Inc., New York, 1976. The design of the improved converter according to the invention accommodates the increase in volume of oil shales, and some coals which may be charged, as they reach their critical temperatures, by gradually increasing the diameter of the stack in the Region 4, which tapers outwardly from the narrowed section 2 at the top. The more central consumption of the carbonaceous grate, achieved by the more central delivery of the oxygen jet blast, also promotes an even downward movement of the burden. As the coal and char forming materials charged at the top descend, the moisture in the charge and the volatile components are driven off and leave the converter through the top. The coke or char remainder moves downward. As the liquid kerogen released in the upper portion of Zone 3 descends it absorbs enough sensible heat from the ascending gas stream to become vaporous and start ascending the stack again. A portion of the ascending gas stream is continuously removed through tuyere sets T4 and T5 carrying with it a major portion of the kerogen vapour. When gas samples taken at these points indicate an undesirable build-up in the stack, additional carbonaceous material is periodically charged and the output through these tuyeres increased to remove it. As the main portion of the gas stream formed in Zone #2 moves up performing the coking process it also preheats approximately 680.4kg (1,500lbs) of acid slag forming constituents produced per ton of oil shale or sands converted.

[0039] Other materials that recycle in the stack interfering with the smooth downward movement of the burden and decreasing lining life are Na, K, KCN, NaCN and Zn and P. Most of them are continuously output through Tuyere set T3. When gas analysis shows the need, a periodic purge is made through tuyere sets T3 and T4. The gases removed through tuyere sets T3, T4 and T5 pass through Waste Heat Boilers 12 and 13 and Trace Sulphur Removal System 23 before delivery to the By-products Plant or that from T3 sent elsewhere as desired. The products when removed from the Waste Heat Boilers are be in a liquid (kerogen and water) or dust form.

[0040] The iron oxide content of the oil shale is reduced in Zone #3. The reduced oxides and the slag constituents

become molten near the top of Zone #2, and trickle down through the carbonaceous grate in Zone #2. they accumulate in the hearth and are periodically withdrawn as in conventional practice. The acidic slag is delivered to the Slag Processing Into Building Materials Unit 20, where it can be poured into igneous rock castings or processed into other building materials.

[0041] When it is desired to use a converter to produce molten metal in an improved manner, mode #4 is employed. The charge at the top 10 will contain metallic oxides in various forms. Only approximately 1/2 of the carbonaceous grate material charged at the top need be premium blast furnace coke with the stability required to resist crushing by a burden heavy with iron or other metallic oxides. The balance of the carbonaceous requirement can be petroleum coke, non-premium coal and optionally some additions of other carbonaceous material. The effectiveness of this smaller amount of premium blast furnace coke is enhanced because of the reduced permeability requirements, (lower volume, no nitrogen in the ascending gas), and other less costly carbonaceous materials provide a major portion of the carbon consumed in producing the process heat and reducing gas required.

[0042] The following is a calculated example of the process for molten metals production:

CHARGE		
	kg	(lbs)
Coarse Iron Ore	409	(902)
Pellets	619	(1,365)
Sinter	536	(1,182)
"B" Scrap	45	(100)
Bosh Slag	68	(151)
Lime Stone	11	(25)
Metallurgical Coke	272	(600)
Form Coke or Pet. Coke	181	(400)
Biomass	64	(140)
Oxygen (Commercial)	336	(740)
Steam (Internally Produced)	286	(630)
TOTAL	2,827	(6,235)

PRODUCT						
	kg	(lbs)	m ³	(cf)	cal/m ³	(BTU/cf.)
Pig Iron	907	(2,000)				
Slag	347	(766)				
Top Gas	1,293	(2,851)	1,040	(36,738)	2,474,000	(278)
Water	254	(559)				
Dust Loss	27	(59)				
Total	2,828	(6,235)				

[0043] There are inherent advantages to converting molten metal producing blast furnaces to converters: less premium coke per ton of molten metal, the simultaneous production of a superior top gas, more tons of molten metal per hour longer lining life and the ability to consume tainted water and other endothermic inputs. The end result is a lower cost per ton of molten metal produced and less pollution. It is possible to gain these advantages by installing only the Zone #1 and #2 improvements detailed herein but even when superior raw materials are charged some will contain trace constituents which tend to cause recycling complications and shorten lining life. To gain full advantage, tuyere sets T3, T4 and T5 also need to be installed along with the sensors located at strategic points which input to the process control computer for calculation of the endothermic and exothermic inputs and outputs. When steam is input, the water gas reaction converts it into carbon monoxide and hydrogen. The hydrogen content of the up moving reducing gas stream is increased, resulting in an increased steam and decreased carbon dioxide content in the top gas. In this mode, all gases leave through the top 9, except during periodic short intervals of recycling material removal. After the moisture

and the sulfur is removed the fuel gas formed will have an energy content of 2,492,000-2,670,000 cal/m³ (280-300 Btu/cf). During brief recycling material purges, gas and vapors are withdrawn through tuyere sets T3, T4 and T5. The process control computer calculates the additional premium blast furnace coke to be charged. The combustion of this coke is required to replace the sensible heat and reducing gas lost to parts of Zone #3 at that time.

[0044] When the major objective is to produce electrical energy without polluting land, air or water, the converter is operated in either Mode #1 or Mode #3. The gas withdrawn through tuyere set #3 after going through the Waste Heat Boiler and the Trace Sulfur Removal System is input into an Electrical Energy Generation Plant. The stack effluent from the plant's boiler is input into the By-products Plant. There it is separated into its components: nitrogen, carbon dioxide and water. The N₂ and CO₂ and H₂O may be sold as products, or the CO₂ alternatively may be converted in the By-products Plant to urea then used in the synthesise of fertilizers and other products. An alternate method is to deliver the top gas to a Blue-Green Algae Greenhouse Tank Farm. There the algae in the pond employ photosynthesis to convert the CO₂ into a health stimulating plant food and pure O₂. Still a further option is to use the CO₂ as the endothermic input through tuyere sets T1 or T2 in the converter. Steam from Waste Heat Boilers 11, 12 and 13 is another product sold or used in the Electrical Generation Plant or elsewhere in the "Improved Converter System".

[0045] The construction and operation of the converter of this invention employ only conventional materials and techniques and, given the teaching of this specification, are easily within the skill of the art. Similarly, the associated systems and associated devices such as injection devices, temperature, liquid and gas detection and analysis equipment, and the like, are commercially available. Computer control systems are also available or can readily be formulated.

[0046] The preferred embodiment of the invention as described in the specification and shown in the drawing is illustrative only. Since modifications will be apparent to those skilled in the art, the invention is limited only by the scope of the appended claims.

Claims

1. A blast furnace having a tapered stack (5), the blast furnace comprising a region (4) where the stack (5) tapers from a normal diameter to a reduced diameter, the stack having a narrowed top section (2) which comprises 15% of the stack height above the bosh and has a constant diameter of the order of 70% to 75% of the diameter that the uppermost portion of the stack would have if the taper of the stack were maintained constant, and five sets of tuyeres, first and second sets of tuyeres (T1 and T2) being located in the bosh, and third, fourth and fifth sets of tuyeres (T3 to T5) being located in the stack above the bosh, wherein the first tuyere set (T1) is located in the hearth above where molten slag and metal are allowed to collect, the second tuyere set (T2) is located above the first tuyere set (T1), the third tuyere set (T3) is located above the second tuyere set (T2) and above the mantel, the fourth tuyere set (T4) is located above the mantel 25% of the distance between the mantel and the top of the stack, and the fifth tuyere set (T5) is located 42% of the distance between the mantel and the top of the stack.
2. A blast furnace according to claim 1, wherein the stack has a tapered transition section which interconnects the top section (2) and the remainder of the stack, the transition comprising approximately 10% of the stack height above the bosh.
3. A blast furnace according to claim 1 or claim 2, further comprising an endothermic material injection system located at the first tuyere set (T1), openings and oxygen jet nozzles and an endothermic injection system located at the second tuyere set (T2).
4. A blast furnace according to any one of claims 1 to 3, further comprising sensing devices at the top, all five tuyere sets and the crucible to sense temperatures at all locations and obtain gas analysis at the third, fourth and fifth tuyere sets (T3, T4 and T5) and the top.
5. A method of operating the blast furnace of any one of claims 1 to 4 as a converter, the method comprising the steps of:
 - a) charging into the top the solid materials to be converted including carbonaceous materials said material moving downwardly through the stack forming a carbonaceous grate in the bosh;
 - b) injecting through the first and second tuyere sets (T1 and T2) all incoming gases, liquids and dusts;
 - c) introducing 100% oxygen jet blast streams (with a small peripheral content of endothermic reacting material) through jet nozzles located in the second tuyere set (T2) at a pressure high enough to enable them to penetrate deeply into the bosh in front of the second tuyere set (T2);

d) combusting in the bosh in front of the second tuyere set (T2) carbon from the carbonaceous grate at high flame temperatures to furnish the process heat required to convert all input materials into a gas, vapour, molten metal, molten slag or dusts;

e) introducing through the first tuyere set (T1) endothermic reacting materials at a pressure slightly greater than that prevailing in the bosh to maintain a zone controlled temperature profile and create a temperature controlled buffer zone located between the high temperature more central portion of the bosh and the walls in the lower part of the converter to protect the refractories, the tuyeres, and injection systems located there from the high flame temperatures employed in the central portion of the bosh;

f) withdrawing gases, vapours and dusts through the third, fourth and fifth tuyere sets (T3, T4 and T5) to remove products and by-products and achieve zone control of the converter's temperature profile;

g) withdrawing slag from the lower portion of the converter;

h) withdrawing metal from near the bottom of the converter; and

i) regulating the volume of endothermic reacting materials input through the first and second tuyere sets (T1 and T2) and/or regulating the oxygen input through the second tuyere set (T2) to control the temperature in the bosh.

6. A method according to claim 5, wherein gases withdrawn from the third, fourth and for fifth tuyere sets (T3, T4 and/or T5) and the top are conducted through waste heat boilers and sulphur removal systems to provide cleaned gases.

7. A method according to claim 6, wherein at least a portion of said cleaned gases are conducted to a synthetic polymer facility.

8. A method according to any one of claims 5 to 7, wherein the molten slag is incorporated into building materials.

9. A method according to any one of claims 5 to 8, wherein said carbonaceous material comprises non-premium coal and other non-premium carbonaceous materials.

10. A method according to any one of claims 5 to 9, further comprising the step of employing a computer using input from sensing equipment located at the third, fourth and fifth tuyere sets (T3, T4 and T5) and the top gaseous stream to regulate the materials injected through the first and second tuyere sets (T1 and T2) to maintain a temperature controlled protective zone between the high temperature central portion of the bosh and the refractory walls of the converter in the bosh.

11. A method according to any one of claims 5 to 10, further comprising the steps of:

a) introducing a charge containing oil shales or oil sands in which the carbonaceous material per ton of oil shale or oil sands will be within a ratio of about 0.6 to 1.2;

b) introducing endothermic reacting materials through the first tuyere set (T1);

c) introducing oxygen and an additional peripheral layer of endothermic reacting material through the second tuyere set (T2);

d) burning the carbonaceous grate material in said charge in the central portion of the bosh to produce the heat required to convert the down moving charge to gases, vapours, molten metal, molten slag or dusts and to provide heat for steps "e" and "f";

e) heating the charge near the top of stack, where the reduced diameter of the stack starts to taper to the conventional diameter to not above 480°C to convert the carbonaceous portion of the charge to coke or char and to preheat the non-carbonaceous portion of the burden;

g) further heating the down moving charge in the central portion of the bosh high enough to convert it to gases, molten slag, molten metal, vapour or dusts;

h) removing molten metal and molten slag from the crucible;

i) continuously withdrawing gases through the third tuyere set (T3) containing recycling materials; and

j) withdrawing useful hydrocarbon gases and kerogen through the fourth and fifth tuyere sets (T4 and T5), and through the top of the stack.

12. A method according to claim 11, wherein at least a portion of the withdrawn cases is conducted to a synthetic polymer plant.

13. A method according to claim 11 or claim 12, wherein the slag is incorporated into building materials.

14. A method according to any one of claims 11 to 13 wherein at least a portion of the withdrawn gases is used for fuel.

15. A method according to any one of claims 5 to 10 to convert municipal and/or industrial wastes having a metallic content into useful by-products, the method comprising the steps of:

- a) introducing a charge containing said wastes, carbonaceous material and slag-forming constituents into the top of the furnace;
- b) introducing endothermic reacting materials through the first tuyere set (T1);
- c) introducing oxygen through the second tuyere set (T2);
- d) burning the carbonaceous material in said charge in the central portion of the bosh to melt slag therein and to provide heat for step e);
- e) heating the charge in the stack to approximately 1,000°C to convert the carbonaceous portion of the charge to coke or char and convert the non-carbonaceous portion to gases, vapours and molten materials;
- f) removing molten metal and molten slag from the crucible;
- g) withdrawing useful gases through the third tuyere set (T3) having an energy content 2,492,000-2,670,000 cal/m³ of (280 to 300 Btu/cf;) and
- h) withdrawing useful gases through the fourth and fifth tuyere sets (T4 and T5), and through the top of the stack.

16. A method according to claim 15, wherein at least a portion of the withdrawn gases is used for fuel.

17. A method according to any one of claims 5 to 10, wherein the charge at the top of the converter contains metallic oxides.

18. A method according to any one of claims 5 to 10, wherein carbonaceous material of biomass origin is input to the top of the converter.

Patentansprüche

1. Blashochofen mit einem verjüngten Schacht (5), wobei der Blashochofen eine Region (4) umfasst, wo der Schacht (5) sich von einem normalen Durchmesser zu einem reduzierten Durchmesser verjüngt, wobei der Schacht ein verengtes oberes Teilstück (2) aufweist, welches 15 % der Schachthöhe über dem Rast umfasst, und einen konstanten Durchmesser im Bereich von 70 % bis 75 % des Durchmessers, welchen der oberste Abschnitt des Schachts haben würde, wenn die Verjüngung des Schachts konstant gehalten werden würde, und fünf Sätze von Blasformen aufweist, wobei erste und zweite Sätze von Blasformen (T1 und T2) im Rast angeordnet sind und dritte, vierte und fünfte Sätze von Blasformen (T3 bis T5) im Schacht über dem Rast angeordnet sind, wobei der erste Blasformsatz (T1) im Gestell über der Stelle, wo geschmolzene Schlacke und Metall sich ansammeln können, angeordnet ist, der zweite Blasformsatz (T2) über dem ersten Blasformsatz (T1) angeordnet ist, der dritte Blasformsatz (T3) über dem zweiten Blasformsatz (T2) und über dem Tragkranz angeordnet ist, der vierte Blasformsatz (T4) über dem Tragkranz 25 % des Abstands zwischen dem Tragkranz und dem oberen Ende des Schachts angeordnet ist und der fünfte Blasformsatz (T5) 42 % des Abstands zwischen dem Tragkranz und dem oberen Ende des Schachts angeordnet ist.
2. Blashochofen nach Anspruch 1, wobei der Schacht ein sich verjüngendes Übergangsteilstück aufweist, welches das obere Teilstück (2) und den Rest des Schachts miteinander verbindet, wobei das Übergangsteilstück ungefähr 10 % der Schachthöhe über dem Rast umfasst.
3. Blashochofen nach Anspruch 1 oder 2, ferner umfassend ein Einblassystem für endothermisches Material, welches an dem ersten Blasformsatz (1), Öffnungen und Sauerstoffstrahldüsen angeordnet ist, und ein Einblassystem für endothermisches Material, welches am zweiten Blasformsatz (T2) angeordnet ist.
4. Blashochofen nach einem der Ansprüche 1 bis 3, ferner umfassend Messfühlervorrichtungen an dem oberen Ende, allen fünf Blasformsätzen und dem Schmelztiegel, um an allen Stellen Temperaturen zu messen und an den dritten, vierten und fünften Blasformsätzen (T3, T4 und T5) und dem oberen Ende Gasanalysen zu erhalten.
5. Verfahren zum Betreiben des Blashochofens nach einem der Ansprüche 1 bis 4 als einen Konverter, wobei das Verfahren die folgenden Schritte umfasst:

a) Füllen der umzuwandelnden Feststoffmaterialien, umfassend kohlehaltige Materialien, in das obere Ende, wobei das Material sich durch den Schacht nach unten bewegt und im Rast einen kohlehaltigen Rost bildet;

b) Einblasen aller ankommenden Gase, Flüssigkeiten und Stäube durch die ersten und zweiten Blasformsätze (T1 und T2);

c) Einführen von Strahlblasströmen 100 %igen Sauerstoffs (mit einem kleinen Randgehalt von endothermischem Reaktionsmaterial) durch Strahldüsen, welche im zweiten Blasformsatz (T2) angeordnet sind, bei einem Druck, der hoch genug ist, um sie zu befähigen, tief in den Rast vor dem zweiten Blasformsatz (T2) einzudringen;

d) Verbrennen im Rast vor dem zweiten Blasformsatz (T2) von Kohle vom kohlehaltigen Rost bei Hochflammentemperaturen, um die Prozesswärme zu liefern, welche erforderlich ist, um alle zugeführten Materialien in Gas, Dampf, geschmolzenes Metall, geschmolzene Schlacke oder Stäube umzuwandeln;

e) Einführen von endothermischen Reaktionsmaterialien durch den ersten Blasformsatz (T1) bei einem Druck, welcher etwas höher ist als jener, der im Rast vorherrscht, um ein zonengesteuertes Temperaturprofil aufrechtzuerhalten und eine temperaturgesteuerte Pufferzone, welche zwischen dem zentraleren Hochtemperaturabschnitt des Rasts und den Wänden im unteren Teil des Konverters angeordnet ist, zu schaffen, um die feuerfesten Stoffe, die Blasformsätze und Einblassysteme, welche da angeordnet sind, vor den Hochflammentemperaturen, welche im zentralen Abschnitt des Rasts eingesetzt werden, zu schützen;

f) Abziehen von Gasen, Dämpfen und Stäuben durch die dritten, vierten und fünften Blasformsätze (T3, T4 und T5), um Erzeugnisse und Nebenerzeugnisse zu entnehmen und zonensteuerung des Temperaturprofils des Konverters zu erreichen;

g) Abziehen von Schlacke aus dem unteren Abschnitt des Konverters;

h) Abziehen von Metall von der Nähe des Bodens des Konverters; und

i) Regulieren des Volumens von endothermischen Reaktionsmaterialien, welche durch die ersten und zweiten Blasformsätze (T1 und T2) zugeführt werden, und/oder Regulieren des Sauerstoffs, welcher durch den zweiten Blasformsatz (T2) zugeführt wird, um die Temperatur im Rast zu steuern.

6. Verfahren nach Anspruch 5, wobei Gase, welche von den dritten, vierten und/oder fünften Blasformsätzen (T3, T4 und/oder T5) und dem oberen Ende abgezogen werden, durch Abhitzekeessel und Schwefelentzugssysteme geführt werden, um gereinigte Gase bereitzustellen.

7. Verfahren nach Anspruch 6, wobei wenigstens ein Anteil der gereinigten Gase zu einer Anlage für synthetisches Polymer geführt wird.

8. Verfahren nach einem der Ansprüche 5 bis 7, wobei die geschmolzene Schlacke in Baumaterialien integriert wird.

9. Verfahren nach einem der Ansprüche 5 bis 8, wobei das kohlehaltige Material nichthochwertige Kohle und andere nichthochwertige kohlehaltige Materialien umfassen.

10. Verfahren nach einem der Ansprüche 5 bis 9, ferner umfassend den Schritt des Einsetzens eines Computers, welcher Eingaben von den Messfühlergeräten, welche an den dritten, vierten und fünften Blasformsätzen (T3, T4 und T5) angeordnet sind, und dem gasförmigen Strom des oberen Endes verwenden, um die Materialien, welche durch die ersten und zweiten Blasformsätze (T1 und T2) eingeblasen werden, zu regulieren, um eine temperaturgesteuerte Schutzzone zwischen dem zentralen Hochtemperaturabschnitt des Rasts und den feuerfesten Wänden des Konverters im Rast aufrechtzuerhalten.

11. Verfahren nach einem der Ansprüche 5 bis 10, ferner die folgenden Schritte umfassend:

a) Einführen einer Charge, welche Ölschiefer und Ölsände enthält und in welcher das kohlehaltige Material pro Tonne Ölschiefer und Ölsände in einem Verhältnis von ungefähr 0,6 zu 1,2 vorhanden ist;

b) Einführen von endothermischen Reaktionsmaterialien durch den ersten Blasformsatz (T1);

c) Einführen von Sauerstoff und einer zusätzlichen Schicht von endothermischem Reaktionsmaterial durch den zweiten Blasformsatz (T2);

d) Verbrennen des kohlehaltigen Rostmaterials in der Charge im zentralen Abschnitt des Rasts, um die Wärme zu erzeugen, welche erforderlich ist, um die sich nach unten bewegende Charge in Gase, Dämpfe, geschmolzenes Metall, geschmolzene Schlacke oder Stäube umzuwandeln und Wärme für die Schritte "e" und "f" bereitzustellen;

e) Erwärmen der Charge in der Nähe des oberen Endes des Schachts, wo der reduzierte Durchmesser des Schachts beginnt, sich zum herkömmlichen Durchmesser zu verjüngen, auf nicht mehr als 480 °C, um den kohlehaltigen Anteil der Charge in Koks oder Holzkohle umzuwandeln und um den nichtkohlehaltigen Anteil des Einsatzgutes vorzuwärmen;

g) ausreichendes Weitererwärmen der sich nach unten bewegenden Charge im zentralen Abschnitt des Rasts, um sie in Gase, geschmolzene Schlacke, geschmolzenes Metall, Dampf oder Stäube umzuwandeln;

h) Entnehmen von geschmolzenem Metall und geschmolzener Schlacke aus dem Schmelztiegel;

i) kontinuierliches Abziehen von Gasen, welche Recyclingmaterialien enthalten, durch den dritten Blasformsatz (T3); und

j) Abziehen von brauchbaren Kohlenwasserstoffgasen und Kerogen durch die vierten und fünften Blasformsätze (T4 und T5) und durch das obere Ende des Schachts.

12. Verfahren nach Anspruch 11, wobei wenigstens ein Anteil der abgezogenen Gase zu einer Anlage für synthetisches Polymer geführt wird.

13. Verfahren nach Anspruch 11 oder 12, wobei die Schlacke in Baumaterialien integriert wird.

14. Verfahren nach einem der Ansprüche 11 bis 13, wobei wenigstens ein Anteil der abgezogenen Gase für Brennstoff verwendet wird.

15. Verfahren nach einem der Ansprüche 5 bis 10 zum Umwandeln von städtischen und/oder industriellen Abfällen mit Metallgehalt in brauchbare Nebenerzeugnisse, wobei das Verfahren die folgenden Schritte umfasst:

a) Einführen einer Charge, welche die Abfälle, kohlehaltiges Material und schlackebildende Bestandteile enthält, in das obere Ende des Ofens;

b) Einführen von endothermischen Reaktionsmaterialien durch den ersten Blasformsatz (T1);

c) Einführen von Sauerstoff durch den zweiten Blasformsatz (T2);

d) Verbrennen des kohlehaltigen Materials in der Charge im zentralen Abschnitt des Rasts, um die Schlacke darin zu schmelzen und um Wärme für Schritt e) bereitzustellen;

e) Erwärmen der Charge im Schacht auf ungefähr 1.000 °C, um den kohlehaltigen Anteil der Charge in Koks oder Holzkohle umzuwandeln und den nichtkohlehaltigen Anteil in Gase, Dämpfe und geschmolzene Materialien umzuwandeln;

f) Entnehmen von geschmolzenem Metall und geschmolzener Schlacke aus dem Schmelztiegel;

g) Abziehen von brauchbaren Gasen, welche einen Energieinhalt von 10.423.840 bis 11.168.400 N/m² von (280 bis 300 Mm/cf) aufweisen, durch den dritten Blasformsatz (T3); und

h) Abziehen von brauchbaren Gasen durch die vierten und fünften Blasformsätze (T4 und T5) und durch das obere Ende des Schachts.

16. Verfahren nach - Anspruch 15, wobei wenigstens ein Anteil der abgezogenen Gase für Brennstoff verwendet wird.
17. Verfahren nach einem der Ansprüche 5 bis 10, wobei die Charge am oberen Ende des Konverters Metalloxide enthält.
18. Verfahren nach einem der Ansprüche 5 bis 10, wobei kohlehaltiges Material von Biomasseursprung zum oberen Ende des Konverters zugeführt wird.

Revendications

1. Haut fourneau comportant une cuve conique (5), le haut fourneau comprenant une région (4) dans laquelle la cuve (5) se rétrécit depuis un diamètre nominal jusqu'à un diamètre réduit, la cuve possédant une section supérieure rétrécie (2) qui occupe 15 % de la hauteur de la cuve au-dessus des étalages et possède un diamètre constant de l'ordre de 70 % à 75 % du diamètre que posséderait la partie la plus élevée de la cuve si la conicité du haut fourneau était constante, et cinq ensembles de tuyères, des premier et second ensembles de tuyères (T1 et T2) étant situés dans les étalages et les troisième, quatrième et cinquième ensembles de tuyères (T3 à T5) étant situés dans la cuve au-dessus des étalages, et dans lequel le premier ensemble de tuyères (T1) est situé dans le foyer au-dessus de l'endroit où le laitier et le métal fondus peuvent se rassembler, le second ensemble de tuyères (T2) est situé au-dessus du premier ensemble de tuyères (T1), le troisième ensemble de tuyères (T3) est situé au-dessus du second ensemble de tuyères (T2) et au-dessus du manteau, le quatrième ensemble de tuyères (T4) est situé au-dessus du manteau à 25 % de la distance entre le manteau et le sommet de la cuve, et le cinquième ensemble de tuyère (T5) est situé à 42 % de la distance entre le manteau et le sommet de la cuve.
2. Haut fourneau selon la revendication 1, dans lequel la cuve possède une section de transition conique qui raccorde la section supérieure (2) et le reste de la cuve, la transition occupant environ 10 % de la hauteur de la cuve au-dessus des étalages.
3. Haut fourneau selon la revendication 1 ou la revendication 2, comprenant en outre un système d'injection d'un matériau endothermique situé au niveau du premier ensemble de tuyères (T1), des ouvertures et des buses de projection d'oxygène et un système d'injection endothermique situé au niveau du second ensemble de tuyères (T2).
4. Haut fourneau selon l'une quelconque des revendications 1 à 3, comprenant en outre des dispositifs de détection situés à la partie supérieure, au niveau de la totalité des cinq ensembles de tuyères et au niveau du creuset, pour détecter les températures en tous les emplacements et réaliser une analyse du gaz au niveau des troisième, quatrième et cinquième ensembles de tuyères (T3, T4 et T5) et au niveau de la partie supérieure.
5. Procédé de fonctionnement du haut fourneau selon l'une quelconque des revendications 1 à 4 en tant que convertisseur, le procédé comprenant les étapes consistant à :
 - a) charger à la partie supérieure les matières solides devant être converties et incluant des matériaux carbonés, lesdites matières descendant à l'intérieur de la cuve en formant une grille carbonée dans les étalages;
 - b) injecter au moyen des premier et second ensembles de tuyères (T1 et T2) tous les gaz, liquides et poussières qui arrivent;
 - c) introduire des courants de jet à 100 % d'oxygène (avec une faible teneur périphérique en matière réagissant par réaction endothermique) par des tuyères de projection situées dans le second ensemble de tuyères (T2) à une pression suffisamment élevée pour permettre leur pénétration profonde dans les étalages en avant du second ensemble de tuyères (T2);
 - d) faire brûler dans les étalages en avant du second ensemble de tuyères (T2), le carbone provenant de la grille carbonée avec des températures de flamme élevées pour produire la chaleur de traitement requise pour convertir l'ensemble des matières introduites en un gaz, une vapeur, un métal fondu, un laitier fondu ou des poussières;
 - e) introduire par le premier ensemble de tuyères (T1) des matières de réaction endothermique à une pression légèrement supérieure à celle régnant dans les étalages de manière à maintenir un profil de température réglé par zones et créer une zone tampon à température réglée située entre la partie la plus centrale à haute température des étalages et les parois dans la partie inférieure du convertisseur pour protéger les matériaux réfractaires, les tuyères et les systèmes d'injection situés en cet endroit, vis-à-vis des températures élevées de flamme utilisées dans la partie centrale des étalages;

f) retirer des gaz, des vapeurs et des poussières par l'intermédiaire des troisième, quatrième et cinquième ensembles de tuyères (T3, T4 et T5) pour éliminer des produits et des sous-produits et obtenir un réglage par zones du profil de température du convertisseur;
 g) retirer le laitier de la partie inférieure du convertisseur;
 h) retirer le métal de la zone proche du fond du convertisseur; et
 i) régler le volume des matières de réaction endothermique introduites par les premier et second ensembles de tuyères (T1, T2) et/ou régler l'entrée d'oxygène par le second ensemble de tuyères (T2) pour régler la température dans les étalages.

6. Procédé selon la revendication 5, selon lequel des gaz retirés des troisième, quatrième et cinquième ensembles de tuyères (T3, T4 et/ou T5) et à partir de la partie supérieure sont conduits à travers des chaudières à récupération de chaleur et des systèmes d'élimination du soufre pour l'obtention de gaz purifiés.

7. Procédé selon la revendication 6, selon lequel au moins une partie desdits gaz purifiés est envoyée à une installation de fabrication de polymères synthétiques.

8. Procédé selon l'une quelconque des revendications 5 à 7, dans lequel le laitier fondu est incorporé dans des matériaux de construction.

9. Procédé selon l'une quelconque des revendications 5 à 8, selon lequel ledit matériau carboné comprend du charbon qui n'est pas de qualité supérieure et d'autres matériaux carbonés qui ne sont pas d'une qualité supérieure.

10. Procédé selon l'une quelconque des revendications 5 à 9, comprenant en outre l'étape consistant à employer un ordinateur utilisant un signal d'entrée provenant de l'équipement de détection situé au niveau des troisième, quatrième et cinquième ensembles de tuyères (T3, T4 et T5), et le courant gazeux supérieur pour régler les matières injectées au moyen des premier et second ensembles de tuyères (T1 et T2) pour maintenir une zone de protection réglée en température, entre la partie centrale à température élevée des étalages et les parois réfractaires du convertisseur dans les étalages.

11. Procédé selon l'une quelconque des revendications 5 à 10, comprenant en outre les étapes consistant à:

a) introduire une charge contenant des schistes bitumineux ou des sables pétrolifères dans un rapport d'environ 0,6 à 1,2;

b) introduire des matières de réaction endothermique par le premier ensemble de tuyères (T1);

c) introduire de l'oxygène et une couche périphérique additionnelle d'une matière de réaction endothermique par le second ensemble de tuyères (T2);

d) brûler le matériau de grille carbonée dans ladite charge dans la partie centrale des étalages pour produire la chaleur requise pour convertir la charge descendante en gaz, vapeurs, métal fondu, laitier fondu ou poussières et fournir la chaleur pour les étapes "e" et "f";

e) chauffer la charge à proximité de la partie supérieure de la cuve, où le diamètre réduit de la cuve commence à diminuer en direction du diamètre classique, à une température non supérieure à 480°C pour convertir la partie carbonée de la charge en coke ou en charbon et préchauffer la partie non carbonée de la charge;

g) chauffer en outre la charge descendante dans la partie centrale des étalages d'une manière suffisante pour la convertir en gaz, laitier fondu, métal fondu, vapeur ou poussières;

h) retirer le métal fondu et le laitier fondu du creuset;

i) retirer continuellement des gaz par le troisième ensemble de tuyères (T3) contenant des matériaux de recyclage; et

j) retirer les gaz d'hydrocarbures utiles et du kérosène au moyen des quatrième et cinquième ensembles de tuyères (T4 et T5) et par la partie supérieure de la cuve.

12. Procédé selon l'une quelconque des revendications 11, selon lequel au moins une partie des gaz prélevés est envoyée à une installation de fabrication de polymères synthétiques.

13. Procédé selon la revendication 11 ou la revendication 12, dans lequel le laitier est incorporé dans des matériaux de construction.

14. Procédé selon l'une quelconque des revendications 11 à 13, selon lequel au moins une partie des gaz retirés est utilisée comme combustible.

15. Procédé selon l'une quelconque des revendications 5 à 10 pour convertir des ordures ménagères et/ou des déchets industriels comportant une teneur métallique, en des produits secondaires utiles, le procédé comprenant les étapes consistant à :

- a) introduire une charge contenant lesdits déchets, un matériau carboné et des constituants formant un laitier, à la partie supérieure du four;
- b) introduire des matières de réaction endothermique au moyen du premier ensemble de tuyères (T1);
- c) introduire de l'oxygène par le second ensemble de tuyères (T2);
- d) brûler le matériau carboné dans ladite charge, dans la partie centrale des étalages, pour faire fondre le laitier dans cette partie et pour délivrer de la chaleur pour l'étape e);
- e) chauffer la charge dans la cuve à environ 1000°C pour convertir la partie carbonée de la charge en coke ou en charbon et convertir la partie non carbonée en des gaz, des vapeurs et des matières fondues;
- f) retirer le métal fondu et le laitier fondu du creuset;
- g) retirer des gaz utiles par le troisième ensemble de tuyères (T3) possédant une teneur en énergie comprise entre 10 423 840 et 11 168 400 N/m² (280 à 300 Btu/cf); et
- h) retirer des gaz utiles par l'intermédiaire de quatrième et cinquième ensembles de tuyères (T4 et T5) et par l'intermédiaire de la partie supérieure de la cuve.

16. Procédé selon la revendication 15, selon lequel au moins une partie des gaz prélevés est utilisée comme combustible.

17. Procédé selon l'une quelconque des revendications 5 à 10, selon lequel la charge à la partie supérieure du convertisseur contient des oxydes métalliques.

18. Procédé selon l'une quelconque des revendications 5 à 10, selon lequel un matériau carboné provenant de la biomasse est introduit à la partie supérieure du convertisseur.

FIG. 1

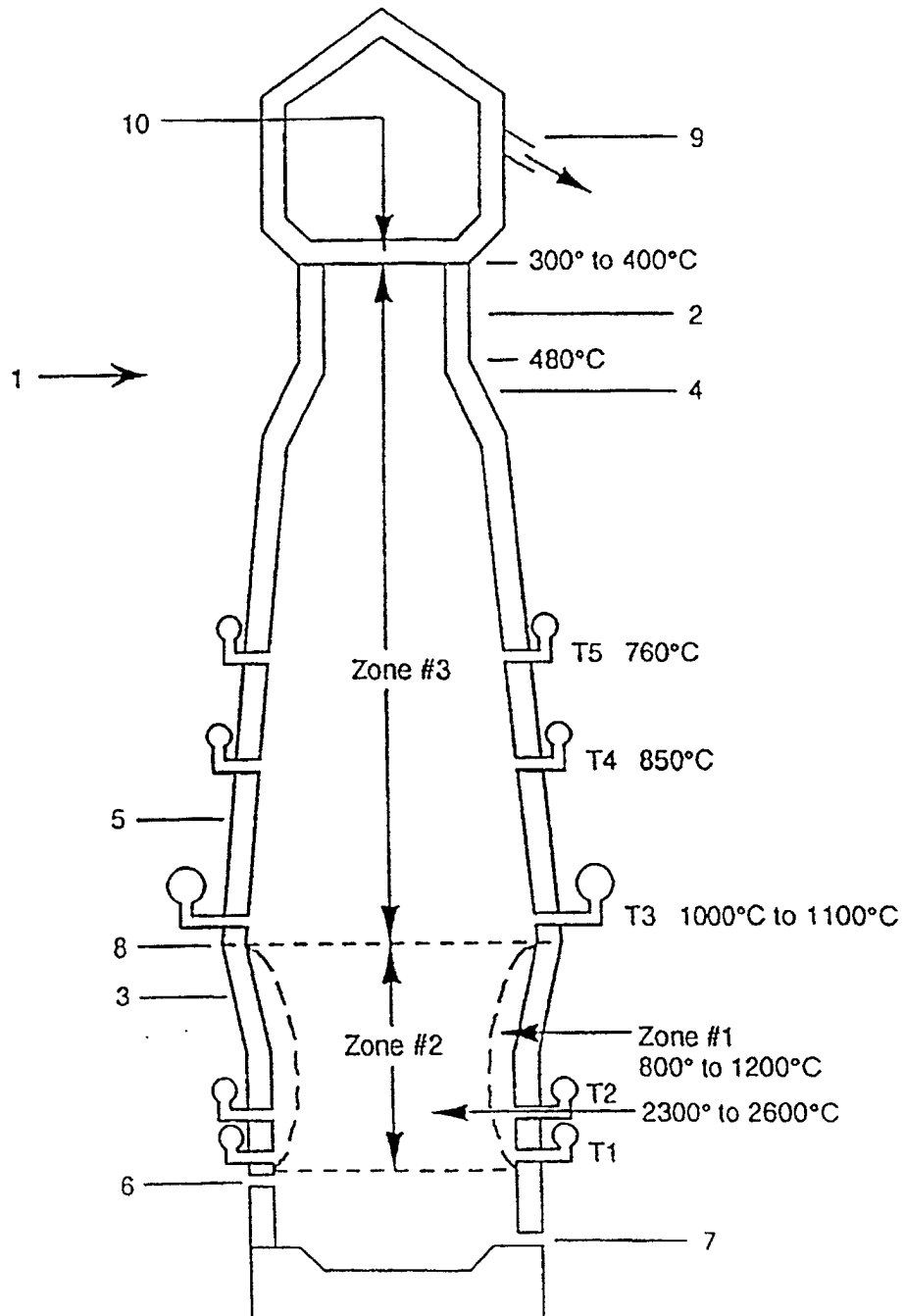


FIG. 2

